# Maritime safety of offshore wind farms. Models versus expert opinions

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**Abstract**
*This paper focuses on the safety aspects of ship traffic in relation to the development of offshore wind farms. This paper focuses on the possible risks coming forward from studies using mathematical models and scenario analysis using information provided by experts in the field. Questions are raised on the observed mismatch between science (models) and practice.*

**Keywords:** risk assessment

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**Introduction**

There is no discussion about the need of alternative energy sources and wind energy fits the current environmental, energy and climate policies of many governments. Offshore wind farms are already a reality at several locations in the world and many more farms are planned. In the Netherlands, the government has set a target of 6.000 Megawatt offshore wind power being installed by the year 2020. Two applications for the development of an offshore wind farm have been granted so far [1]. Moreover 57 initiatives are in preparation in the Dutch EEZ, of which a considerable number is expected actually to be realised (see figure 1). The spatial area involved stresses the need for optimal planning to secure both economic and environmental values of the North Sea, as spatial claims by other activities are very large already. The Dutch coastal waters and North Sea have one of the heaviest shipping traffic in the world [2] (see Figure 2). Maritime safety of offshore wind farms was addressed as a major issue at the Conference "Offshore Wind Farms and the Environment" in Billund in 2004 and is an important aspect of concern for the North Sea surrounding countries. A location permit might not be granted when the safety of other users of the North Sea is at risk or when the chances for ecological damage become unacceptably high. Therefore the issue of risks of ship collisions and interference between ships and wind farms is considered of high importance, as the potential risk could be high for wind farm operations (installation, production and maintenance) as well as for the marine environment.

**Background**

The Dutch part of the North Sea can be classified as a region with an intense nautical traffic density. This heavy shipping traffic on the North Sea is regulated by the use of shipping lanes. To a large extend the international transport (bulk carriers and tankers) together with short sea shipping (coasters) and ferry services can be categorised as ‘route bound traffic’ and follow the compulsory clear ways. However, 50% of the total traffic randomly finds its way manoeuvring either through deep North Sea waters or following the Dutch shore line. This is mostly related to fishing activities and other activities with destinations at sea involving often relative small vessels. Traffic not bound to the clearway’s will have to be rerouted leading to increased density elsewhere.

Positioning large scale offshore wind farms will pose extra stress upon the spatial use of the North Sea. Wind farms will be build outside the shipping lanes resulting in relative large areas in the North Sea in which no traffic will be allowed. Up to now, off shore oil platforms and shipwrecks are the only man made stationary objects to be considered regarding ship traffic safety.

Yet, according to the ongoing development regarding sustainable energy sources, pioneer-projects and plans to build and exploit a significant amount of near shore and offshore windmill parks soon will outgrow its present infant diseases. There is no doubt that significant amounts of these future parks will have some sort of influence by ‘patching-up’ an open sea. However, to which extend these positive or negative effects of offshore windmills in the North Sea can be fully predicted or modelled still is subject to discussion.

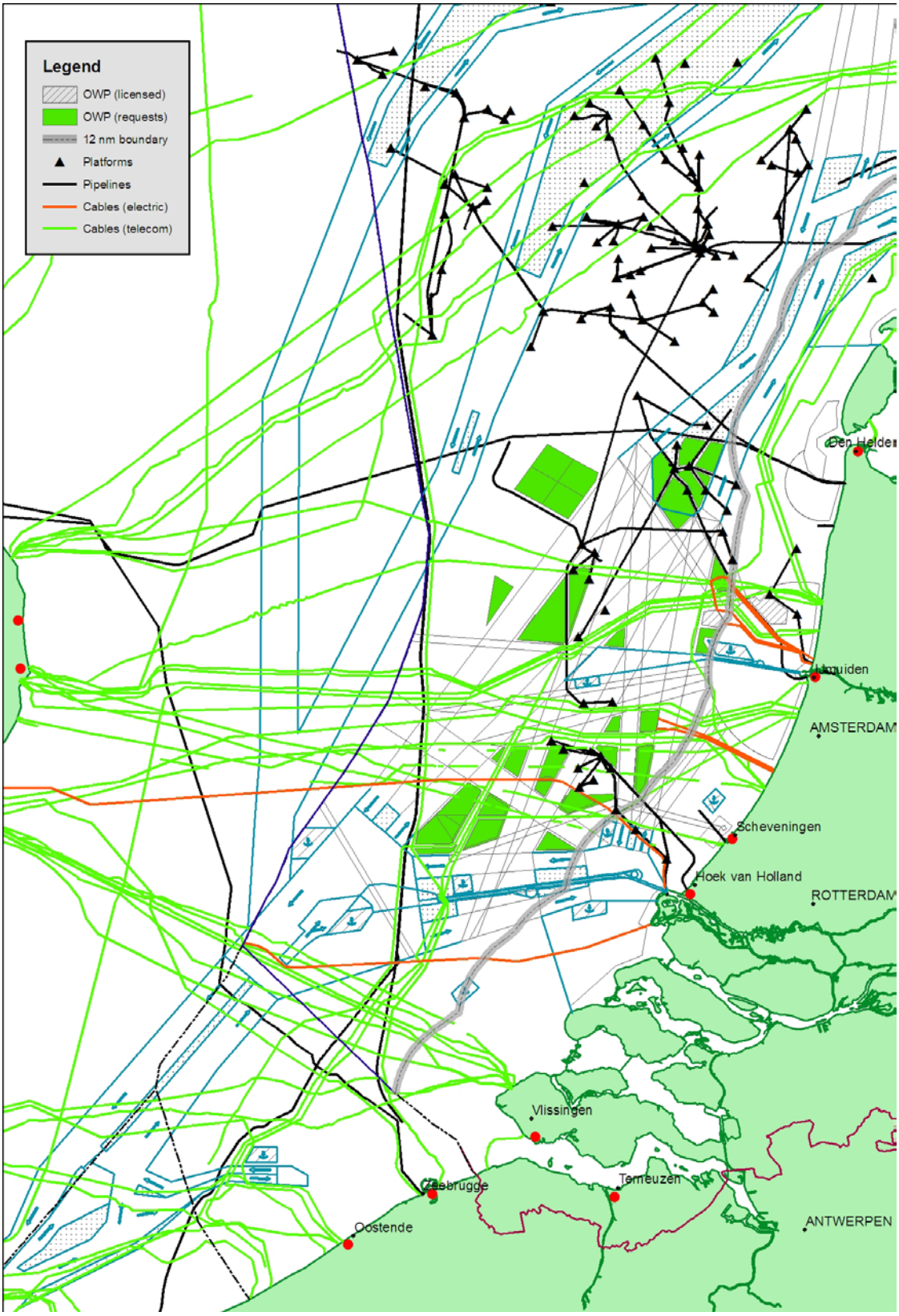


*Figure 1. Overview of planned locations of the wind farms (green areas) off the West coast of the Netherlands and the ship traffic lanes in blue. (Source: Ministry of Transport Public Works and Water Management).*

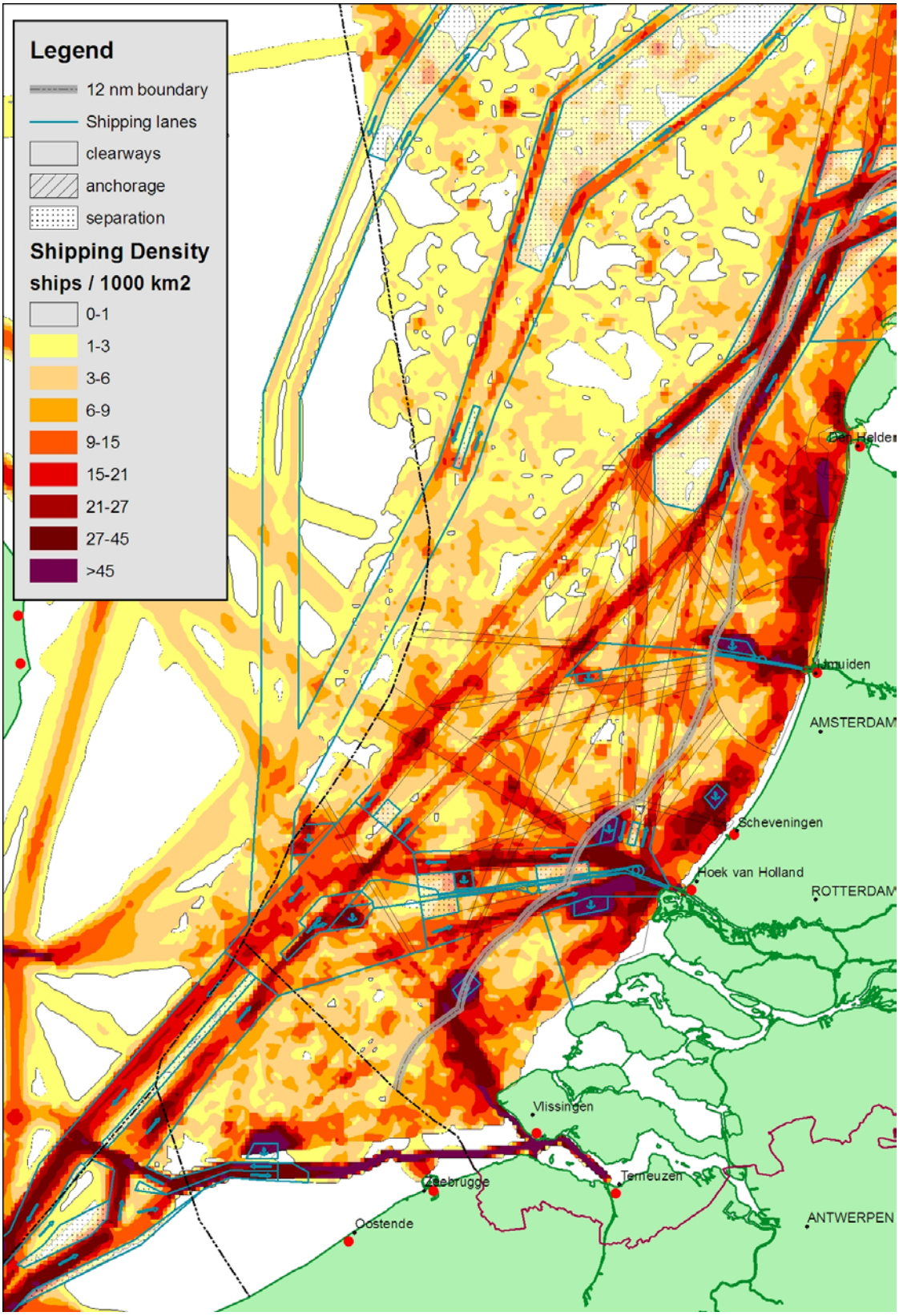


*Figure 2. Vessel traffic on the North Sea (1999-2001). (Source: Ministry of Transport Public Works and Water Management).*

The safety of wind farms in relation to ship activities has been an issue since plans for wind farms were emerging and several studies have been carried out since then [3]. The present studies make use of highly scientifically models and the theoretical basis is for the moment beyond question. The results of such modeling studies indicate that the probability of a ship collision is hardly increasing by the presence of wind farms near the shipping lanes. Therefore these studies give no reason to adjust the current attention for safety risk of offshore wind farms. An important assumption that is made, however, is that all route bound traffic follows the compulsory 'clearways' –human factors or daily practice (alternative routes, near misses) are taken into account. Mostly, separate park initiatives are subdued to separate calculations, taking an open sea (without other parks) as a starting point. As earlier mentioned over 50 applications are currently in preparation involving almost 30 locations for development.
A further point of departure is that smaller vessels will only have a minor impact given a collision with a wind turbine. Drifters are some more point of discussion. Drifters in a wind farm may occur at a chance of once every three years. At Horns Rev in Denmark about 75,000 maintenance movements had to be carried out within a period of one and half year with [4].

Given the situation above the question rises to which extend the existing experience is applicable to the Dutch situation.

**We@Sea: offshore wind research programme**
In the Netherlands the knowledge consortium We@Sea (www.we-at-sea.org) leads a national research- and development programme aimed at generating knowledge and improve and accelerate large scale development of offshore wind energy in the North Sea. The We@Sea programme is characterized by an integrated and interdisciplinary approach in order to provide a minimum risk of uncertainties. Risk reduction and security control of offshore wind farms is part of the work package "Spatial planning and environmental aspects". The Netherlands Organization for Applied Scientific Research TNO is partner in the We@Sea Consortium and involved also in studies related to the environment and spatial planning. The question of the maritime safety of the offshore wind farms in the North Sea is part of a project that TNO is currently executing within the We@Sea consortium.

Risk for offshore wind farms can be considered two sided: 1) risks to traffic (ships, planes) and 2) risk to wind farm operations. Concerning maritime traffic, the risks results from an increased chance on ship collisions, the occurrence of drifters, turbines, power stations and cables being damaged and evolving risk by lost or drifting loads, spills of harmful substances, ecological impacts etc. Due to the development of wind farms obstacles (turbines) are introduced in the yet "empty and open" sea. Depending on the location of a wind farm, these obstacles will lead to a certain increase of the risk for a collision. The exclusion zone of a wind farm will forge traffic to adjust their routes. Due to the relative large areas occupied by the wind farms, especially traffic which is not bound to the clearways will have to be rerouted leading to increased density elsewhere. It is therefore important not only to assess the effect of a single wind farm, but also to assess the cumulative effects of increasing numbers of wind farms, especially in the Dutch marine water knowing relatively intense traffic.
From an economic point of view, next to a fall in energy production and cost of repair, a reduction of risks might be very interesting concerning the insurance. The insurance premium for a wind farm is higher offshore than onshore. This premium might be lowered when the external risks for offshore wind farms are reduced and the party responsible for damage is traceable. This brings up the question if it is advisable to invest and if yes, in what should these investments being made to enlarge the safety of offshore wind farms. Can acceptable investments lead to increased safety and therefore reduced insurance premiums?

**Wind farm safety aspects**
TNO conducted a scenario analysis involving all phases of the life cycle of an offshore wind park. As part of this safety study, discussions and interviews were held with experts in the "field" including the Coast Guard, Sea pilots and other involved parties, amongst others representatives of the Ministry of Transport, Public Works and Water Management, North Sea Directorate responsible for shipping safety. So far these interviews have resulted in qualitative thoughts about the risks. Important aspects that come forward are:

- The construction phase may lead to a substantial increase of shipping traffic, taking into account that only certain periods are suitable for transport.
- During the construction phase additional attention is needed to warn ships in the area where building activities are going on. A minimum distance between parks will have to be kept and specific measures might be needed during the construction phase including guard ships on location warning and guiding the non-bound traffic such as fishing ships.
- During the operation phase the necessary maintenance activities may put more pressure on the traffic in general due to increasing shipping traffic and possible air traffic by helicopters. In the case of severe damage, dedicated ships will be needed.
- The presence several wind farms will increase the risks caused by occurrence of drifters. Larger vessels may have a cumulative impact to wind farms; resulting in increased traffic for repair and to safeguarding of drifters inside the parks.
- The increased number of fixed obstacles (turbines) at sea taking into account the fact that already now near misses occur daily (although hardly reported).
- Economical constraints, waning seamanship, the often poor visibility on the North Sea, drifters, specific locations on the North Sea, increasing ship tonnages making the manoeuvrability more difficult.
- The behaviours of the fishing fleet, as fishing boats are most involved in accidents on the North Sea.
- Radar signals will be influenced by the presence of obstacles such as large turbines. This is also a point for air traffic and has to be solved adequately as air traffic is large as well in the Dutch EEZ.
- Apart from damage to wind turbines by drifters is the question what will be the consequences of damage to a transformer unit of a park or to the high tension cables (36 to 110 kV)

When the process of building and operation is analyzed more in detail, even more aspects of concern might turn up from the "field experts" point of view.
All these aspects play a role in risk assessment (chance of occurrence) and risk evaluation (what is acceptable), but are difficult to introduce in theoretical models which are currently used in risk assessment studies concerning offshore wind farms.

Next to the discussions with experts in the field, a survey upon the existing mathematical models developed calculating the probability of both ship-ship collisions and ship-windmill encounters was carried out. Surprisingly, the 'theoretical' outcome of the matter lies far apart from the pilots' viewpoint ('gut feeling').

**Discussion**

Imagine the energy market takes the opportunity and is ready to invest and build tomorrow? If the risk to maritime traffic is small and acceptable as present studies indicate, to which extend investments are needed and justified to reduce the risks to traffic or to prevent collision damage (e.g. fender systems) even further?

If the risk is at a higher level, as the experts in the field suggests, additional measures need to be considered next to the international required obligations to mark wind farms to ships and air traffic by radar beacon, lights and mist horns.

The opinions concerning the risks of offshore wind farms on the North Sea still seems to vary considerably. This influences the discussion what measures are really necessary also in the light of the reliability of power supply, safety, consequences for personnel and to the marine environment. There is a need for a more in depth discussion how to weigh the perceived dangers and what measures are really necessary in order to carry out a more appropriate analysis. We might even need to develop a new traffic philosophy for the North Sea including additional risk assessment methodologies.

Due to the importance of safety both for the operators, other users of the North Sea and the environment questions to whether science will meet practice should be taken up in order to develop a sustainable industry.

**References**


[1] Initiatieven voor windturbineparken op de Noordzee. Situatie 17-05-2005

[2] Database traffic density North Sea

[3] Seminar “Maritime Safety of Offshore Wind Farms
Wageningen (NL), 21 January 2005.

[4] Horns Rev reveals the real hazards of offshore wind
Modern Power Systems
October 2004, pp 27, 29